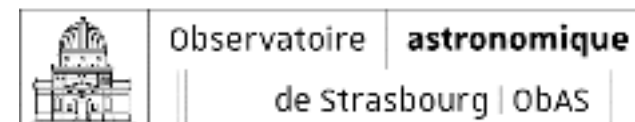


# Intro to the IVOA

Interop meeting 25-29 April 2022

Ada Nebot



[ada.nebot@astro.unistra.fr](mailto:ada.nebot@astro.unistra.fr)

# □ The VO and the IVOA: what?

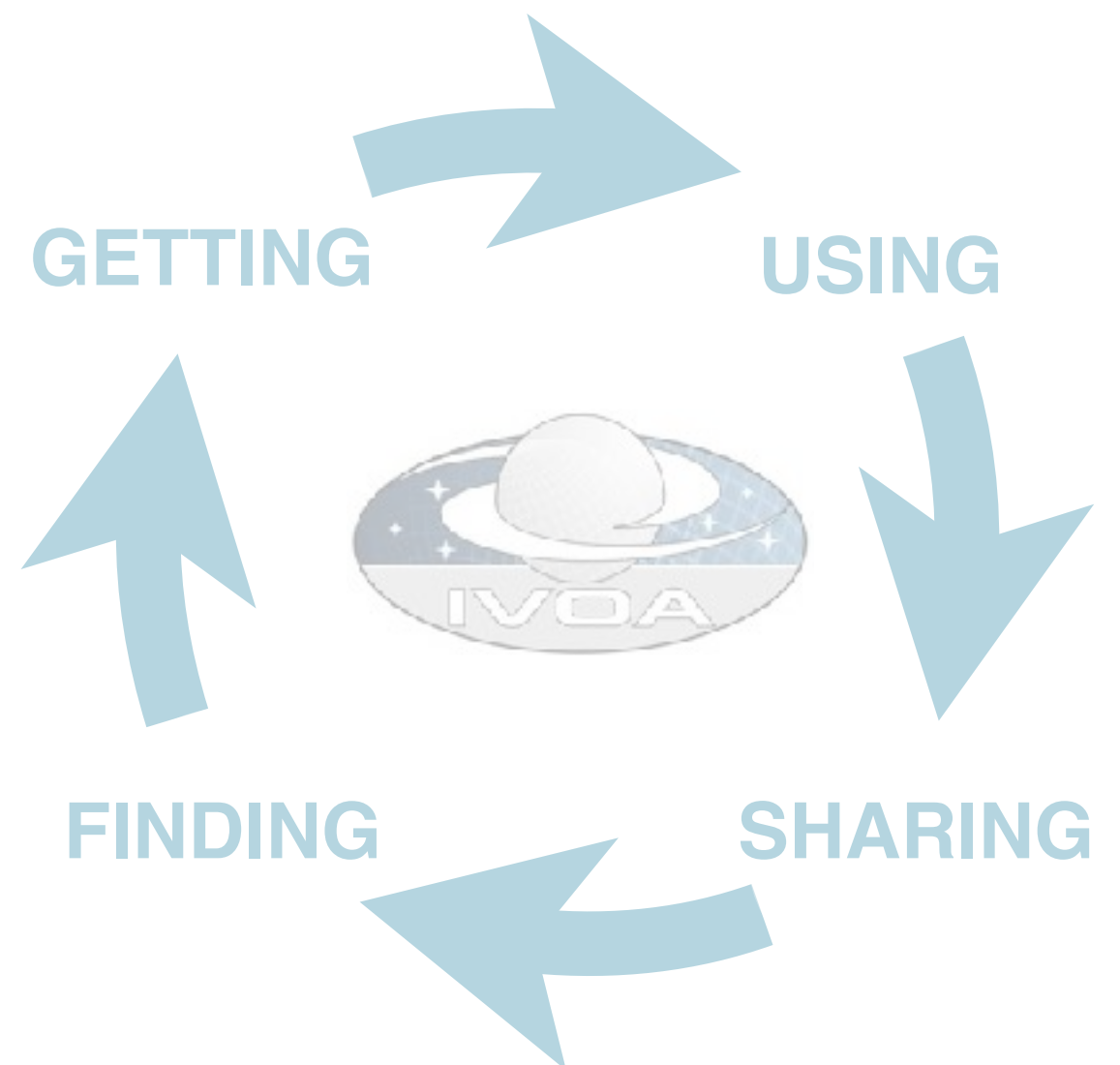
*“A multi-wavelength digital sky that can be searched, visualised and analysed in new and innovative ways” P. Fabianno*

## What is the Virtual Observatory?

- Framework for astronomical datasets, tools, services to work together in a seamless way

## What is the International Virtual Observatory Alliance?

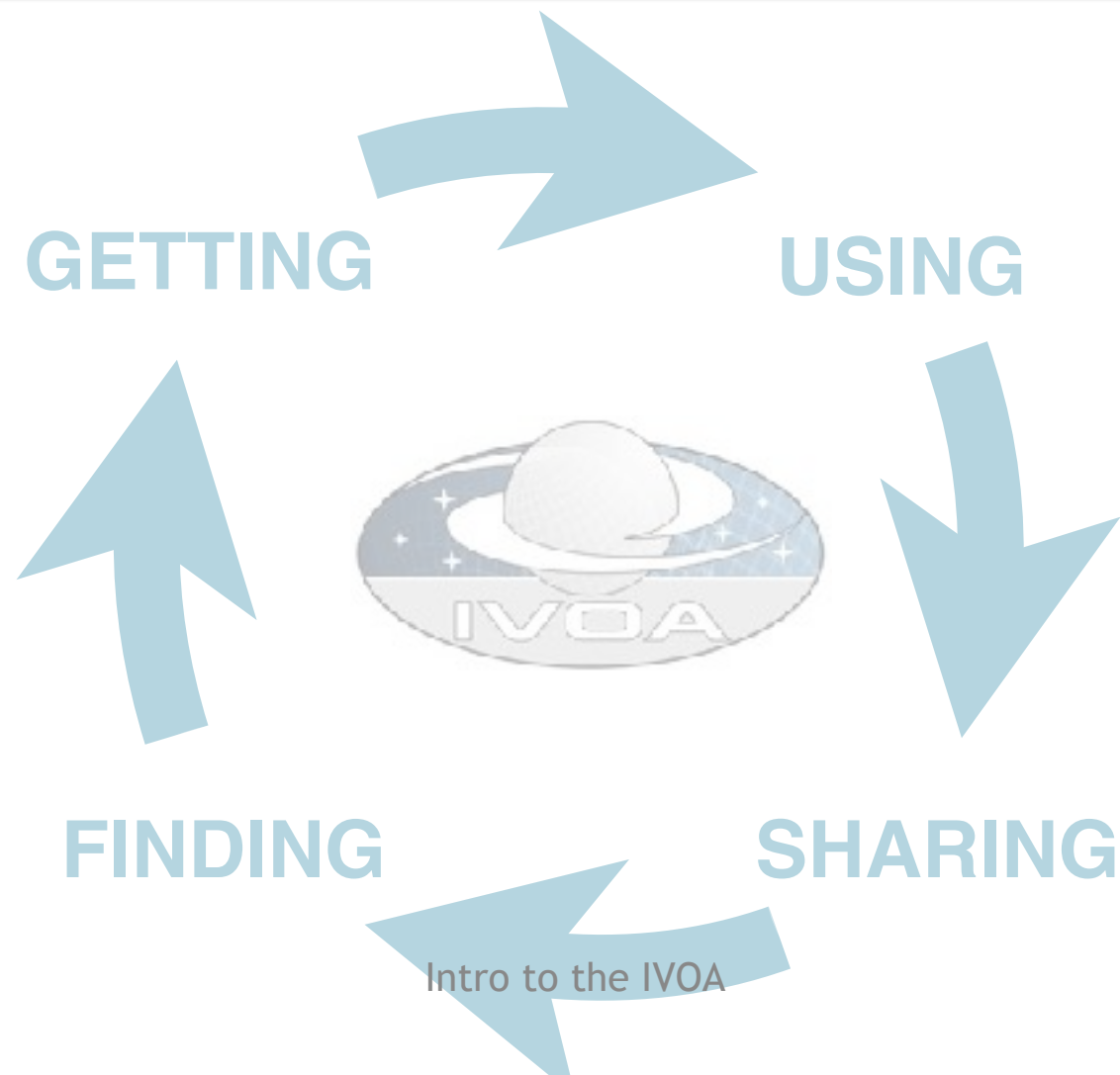
- A science driven organisation that builds the technical standards
- A place for discussing and sharing VO ideas and technology to enable science
- Promoting and publicising the VO



# □ The VO and the IVOA: why?

## Clear benefits

- Growth in the scientific return of data
- Capability to discover and fuse multiple data sets
- Application of the VO in planning new observations and observing strategies



# □ The VO and the IVOA: who?

## Who is the IVOA?

<http://ivoa.net/>

- **5 Committees:** Exec, Tech Coordination, Standards & processes, Media, Science priorities
- **6 Working Groups (WG):** Applications, access, models, grid & web services, registry, semantics
- **8 Interest Groups (IG):** Time-domain, radio, solar system, education, data curation, knowledge & discovery, theory, operations

## Want to get involved?

- Meetings: 2 interoperability meetings per year
- Don't know where to start? Email any chair/vice-chair of a IG/WG, CSP





# □ The VO and the IVOA: where?

**Existing global framework:** populated by major data providers (space and ground based) that is heavily used by the community (e.g. Gaia data access is fully VO)



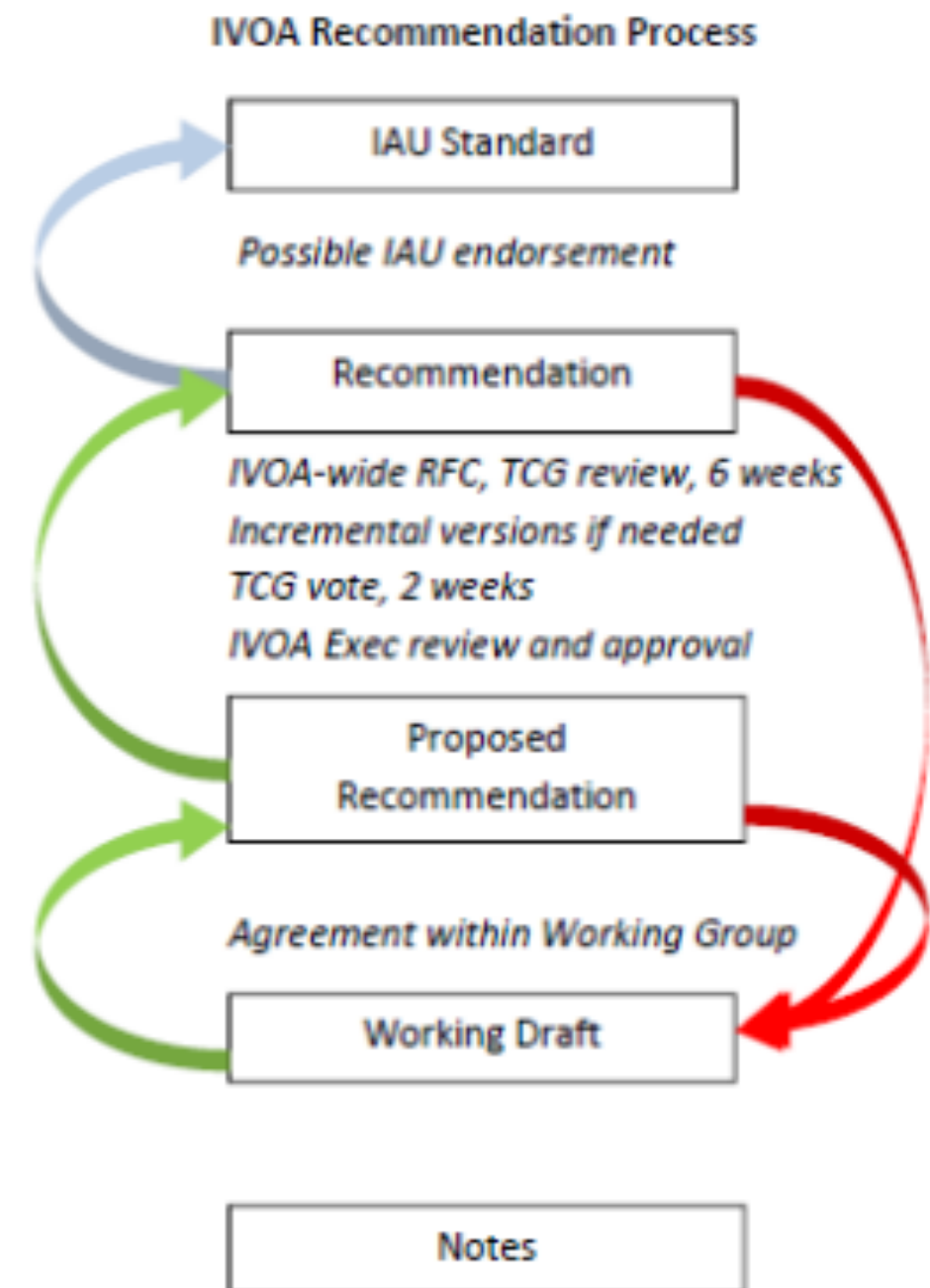
# □ The VO and the IVOA: how?

Through the **development and adoption** of common standards scientifically driven, as an international community effort where astronomers, software engineers and documentalists are involved



# □ IVOA development process of standards

- Build IVOA standards to match users needs:
  - Find and report the community needs
  - Find and report gaps in the existing standards
  - Propose new ways to fill the gaps
  - Implement & validate
  - Standardise when consensus is reached



<https://www.ivoa.net/documents/DocStd/index.html>

# □ OK, but where do I start?

- A good starting point to newcomers to the IVOA: **the architecture document** (more on slide 22)

<https://www.ivoa.net/documents/IVOAArchitecture/20211101/index.html>

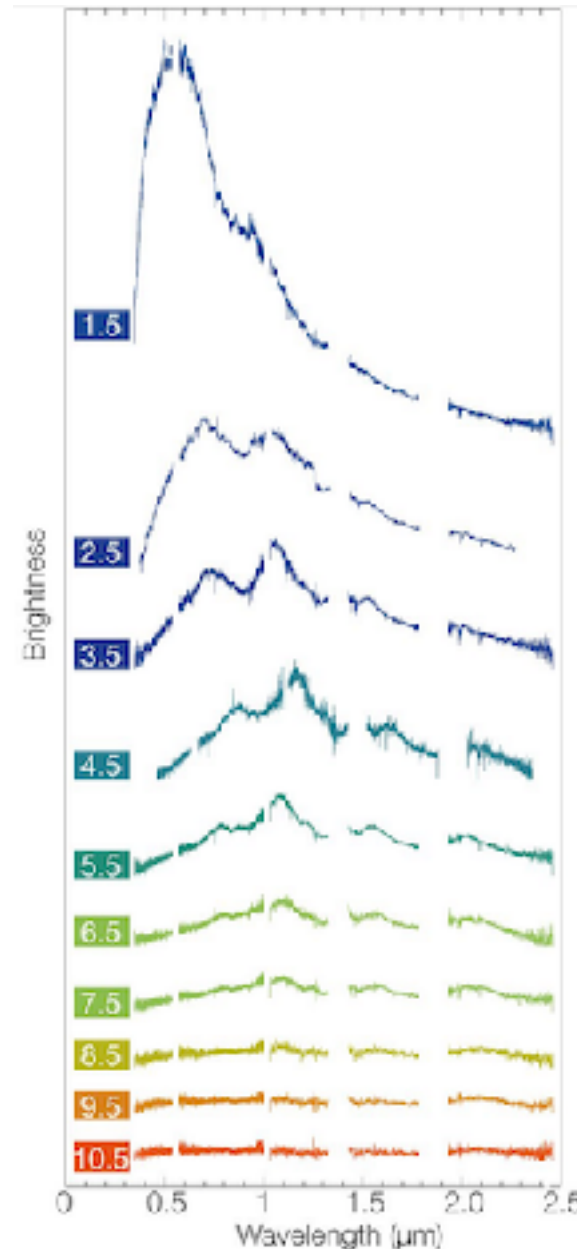
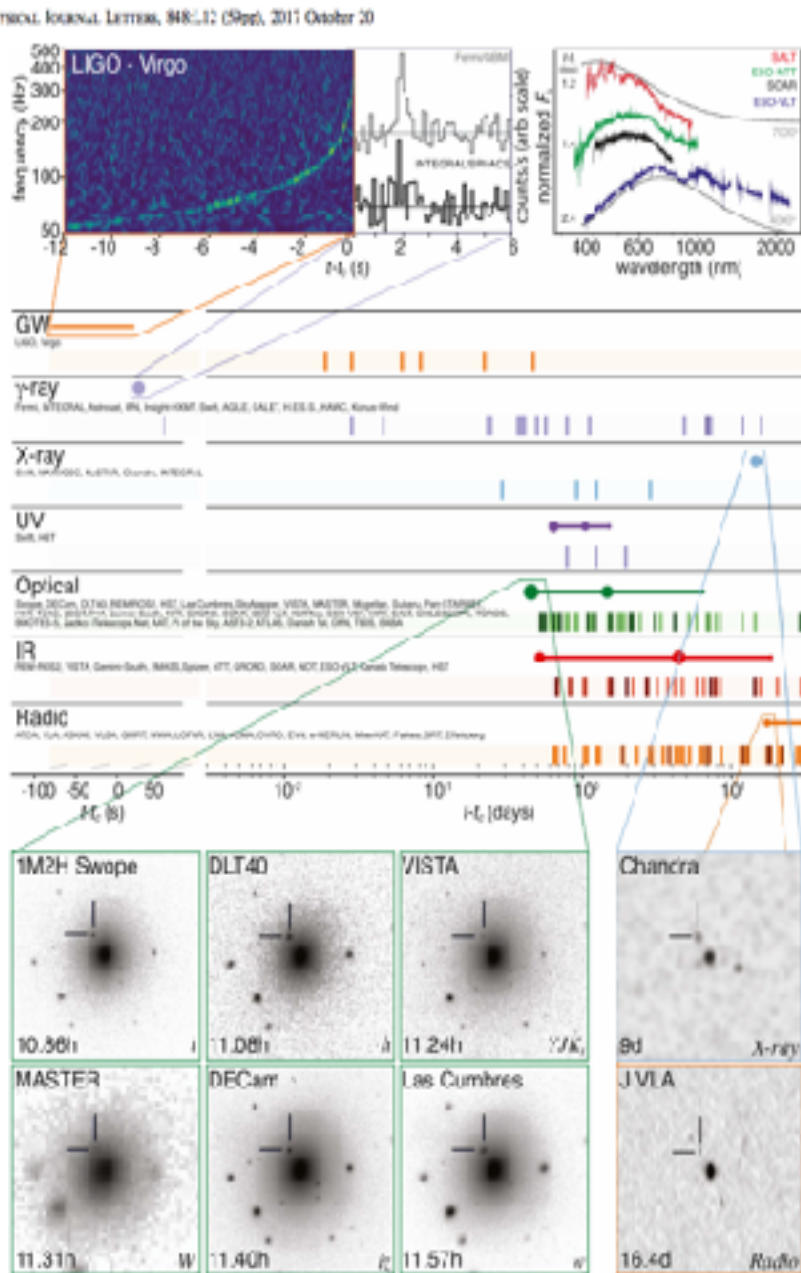
Things to keep in mind:

- The IVOA will not answer your scientific questions nor will it ask the questions for you
- The IVOA provides you with common formats and common ways of describing and accessing the data which when adopted will ease your work

Let's see it with an example



# VO in the multi-messenger landscape



- Multi-wavelength / messenger approach is needed - different data types
- Follow-up observations and reaction time for that can be crucial - alerts
- Analysis, Visualisation & navigation through the data
- Coordination & transmission of information

**The IVOA should match user's needs**

# □ Some selected standards

1. **VOTable** the format for tabular data for allowing interoperability (coosys, timesys, ucd, utype, VOunits, datalink).
2. **HiPS** more than a format for images - tailored for large data volumes
3. Search for data:
  - **Cone search** — spatial + temporal search
  - **MOC** — spatial and temporal indexing for large data volumes and more complex areas in the sky
  - **TAP + ADQL** — Table Access Protocol & astronomical data query language
  - **ObsCore & ObsTAP** — description of observations
4. Planning of observations:
  - **ObjVisSAP** — visibility of object to plan observations
  - **ObsLocTAP** — facilitate coordination of observations
  - Facilities / observatory list (under dev.)
5. Alerts: **VOEvents**
6. ... many more! **SLAP, SIAP, SSA, Provenance, SAMP...** each tailored to specific use cases

# □ VOTable: format for tabular data

Standardisation of coordinate system annotation (time and space), UCD, utypes, VOUnits, datalink

- **COOSYS** ("ICRS", "eq\_FK5",...)
- **TIMESYS** (scale: TT, TAI, ..., reposition: barycenter,... timeorigin: JD, MJD,...)
- **Unified Content Descriptor (UCD)**: controlled vocabulary for describing astronomical data quantities - related to the nature of the values
- **UTypes**: relationship between the columns and the data model components
- **VOUnits**: units expressed as a simplified text label (e.g. m.s-2 instead of m s<sup>-2</sup>)
- **Datalink**: links to other associated data



# □ HiPS: Hierarchical image Progressive Survey

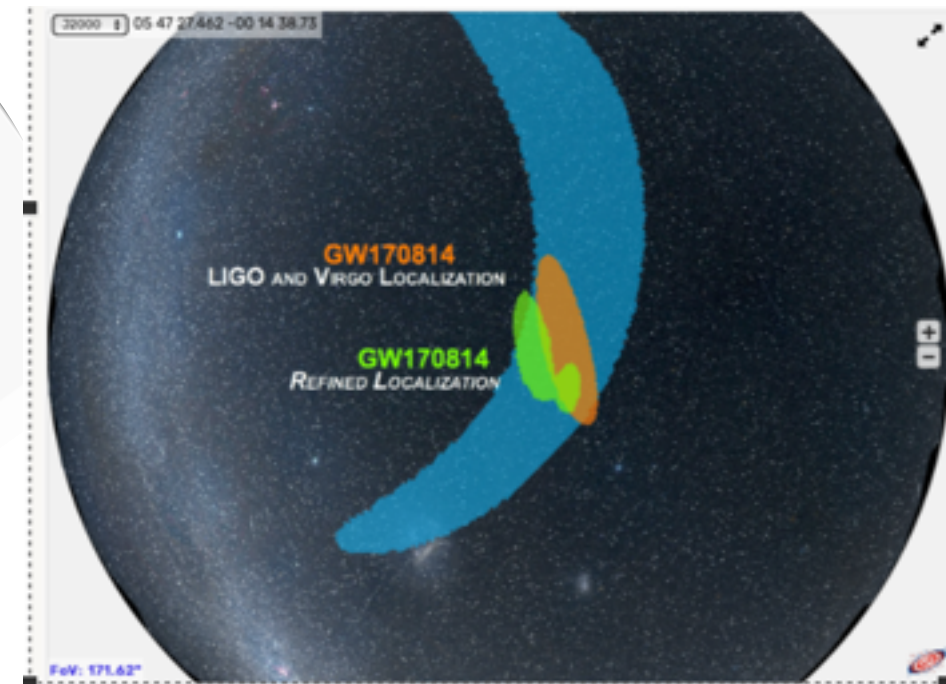
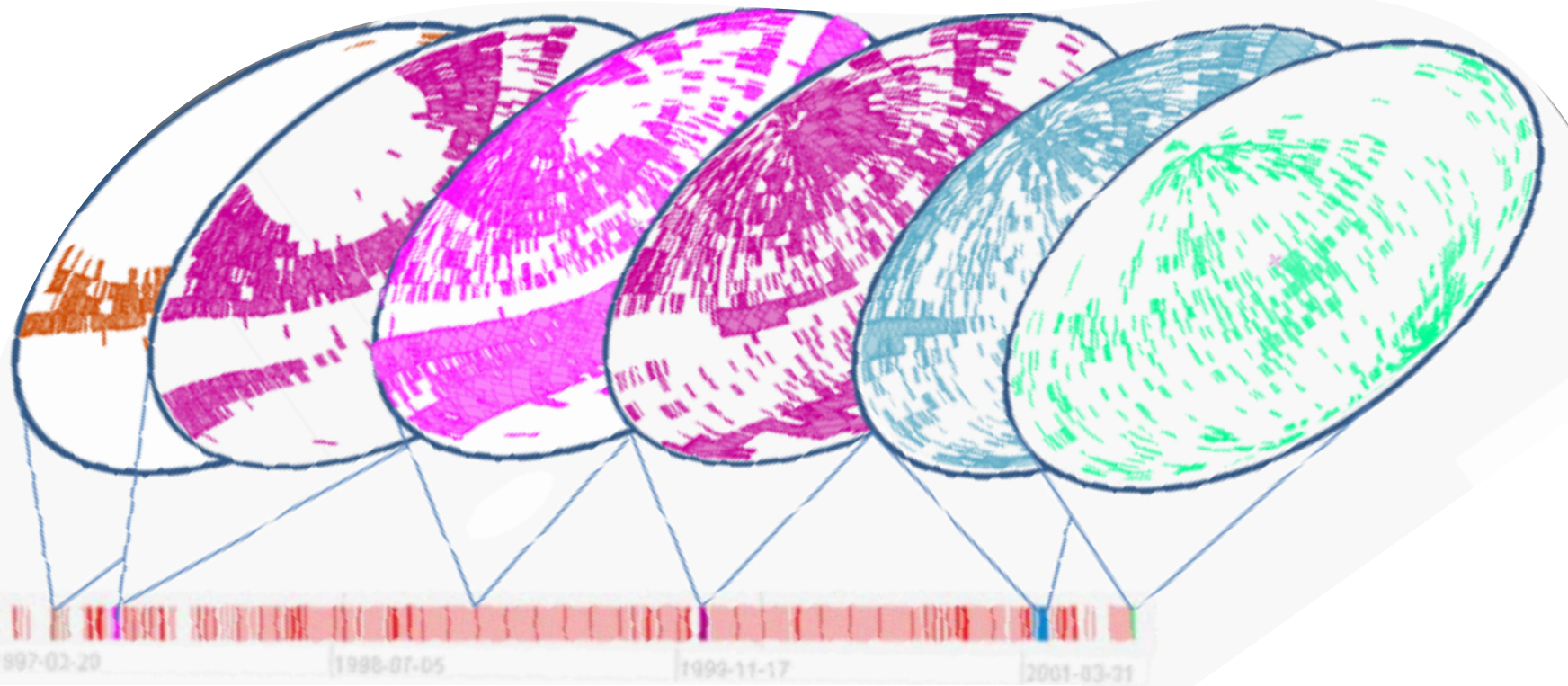
- A hierarchical scheme for the description, storage and access of sky survey data (the more you zoom-in the more the details)





# □ Search: know where & when

- Cone search extension to add a time interval for search in catalogs
- MOC : Search by temporal+spatial coverage of surveys for the more complicated areas



# □ TAP & ADQL

- **Table Access Protocol (TAP)** - defines a service protocol for accessing general table data, including astronomical catalogs as well as general database tables. Access is provided for both database and table metadata as well as for actual table data.
- **Astronomical Data Query Language (ADQL)** Based on Structured Query Language (SQL) with special restrictions and extensions in order to support generic and astronomy specific operations

```
SELECT DISTANCE (  
    POINT('ICRS', 266.41683, -29.00781),  
    POINT('ICRS', ra, dec)) AS dist, *  
FROM gaiaedr3.gaia_source  
WHERE 1=CONTAINS(  
    POINT('ICRS', 266.41683, -29.00781),  
    CIRCLE('ICRS',ra, dec, 0.08333333))  
ORDER BY dist ASC
```

# □ ObsCore & ObsTAP

- **Goal: “to give data providers a set of metadata attributes that they can easily map to their database system in order to support queries of the sort listed below.”**
- Science cases:
  - Support multi-wavelength as well as positional and temporal searches.
  - Support any type of science data product (**image, cube, spectrum, time series, instrumental data, etc.**).
  - Directly support the sorts of file content typically found in archives (FITS, VOTable, compressed files, instrumental data, etc.).

**ObsCore & ObsTAP are Key IVOA standards for searching, finding and combining all sorts of data and allow for interoperability**



# □ ObsCore & ObsTAP

- Map the METADATA of your project data into ObsCore Keywords
  - Set a TAP Service
  - Register it! —> *“The yellow pages of the IVOA”*
- ➡ Search, find, and combine the data coming from multiple missions



# □ Visibility of an object

The screenshot shows the ESO website's 'Object Visibility' tool. It features a search bar, a list of observatories, and a section for 'Object Coordinates (J2000)'. The tool is designed to help users determine the visibility of celestial objects from various ESO observatories.

The screenshot shows the 'XMM-NEWTON MULTI-TARGET VISIBILITY CHECKER'. It includes a 'Target Name' field, a 'Simbad Lookup' button, and a 'Visibility Results' section. The results section displays target details such as RA, Dec, and visibility information for the XMM-Newton observatory.

The screenshot shows the 'ISAAC NEWTON GROUP OF TELESCOPES' website's 'Object Visibility - STARALT' tool. It features a 'Mode' dropdown set to 'Staralt', a 'Night' selector for October 2017, and an 'Observatory' dropdown set to 'La Silla Observatory'. A graph shows the visibility of an object over time, with a peak in visibility around the middle of the night.

The screenshot shows the 'ESO Sky Calendar Tool' interface. It displays the observability for a specific date and time, including the local time, moon phase, and a table of object visibility data. The tool is used to plan observations and understand the local conditions at the observatory.

The screenshot shows the 'XMM-NEWTON AD17 TARGET VISIBILITY CHECKER'. It includes a 'Target Name' field, a 'Search' button, and a table of results. The table lists target names, RA, Dec, and visibility information for the XMM-Newton AD17 observatory.

The screenshot shows the 'ISAAC NEWTON GROUP OF TELESCOPES' website's 'Object Visibility - STARALT' tool. It features a 'Mode' dropdown set to 'Staralt', a 'Night' selector for October 2017, and an 'Observatory' dropdown set to 'La Silla Observatory'. A graph shows the visibility of an object over time, with a peak in visibility around the middle of the night.

Different services have different inputs / outputs  
 Facilitate the work by having some level of standardised input / output



# Coordination of observations

## Integral Target and Scheduling Information

Schedule: **All executed** **Current revolution (1872)** **Future schedule** Revolution **1872** to **1872** **Show...** **show plot**

### Schedule for revolution 1872

(this list is also available in csv-format, click [here](#) to download)

Rev	Start time (UTC)	End time (UTC)	Exp. time (s)	Target	Ra (J2000)	Dec (J2000)	Pattern	PI	Propo
1872	2017-10-10 10:29:15	2017-10-10 17:10:51	12690	Gal. Bulge region	17:45:36.00	-26:56:00.0	LICK	Erik Saulkers	14200
1872	2017-10-10 17:13:34	2017-10-11 07:55:55	30090	Galactic Center	17:52:11.21	-25:21:49.7	5x5_Seq	Joem Wilms	14200
1872	2017-10-11 08:16:46	2017-10-11 11:58:32	12690	Galaxy (l=0, b=0)	17:42:23.76	-29:38:02.4	HEX	Rashid Sunyaev	14200
1872	2017-10-11 12:26:36	2017-10-11 12:56:36	1890	Galaxy (l=0, b=30)	20:02:16.80	-41:20:31.2	HEX	Rashid Sunyaev	14200
1872	2017-10-11 13:27:21	2017-10-11 14:29:17	3090	Galaxy (l=0, b=30)	19:59:40.90	-41:05:06.0	LICK	Rashid Sunyaev	14200
1872	2017-10-11 15:00:12	2017-10-11 17:38:07	9090	Galaxy (l=0, b=30)	19:59:40.80	-41:05:06.0	HEX	Rashid Sunyaev	14200
1872	2017-10-11 18:41:00	2017-10-12 08:01:56	45090	GRS 1915+105	19:15:11.79	+10:56:45.7	5x5_Seq	Jerome Rodriguez	14200
1872	2017-10-12 08:01:56	2017-10-12 13:47:54	12690	Galaxy (l=0, b=30)	20:02:16.80	-41:20:31.2	HEX	Rashid Sunyaev	14200
1872	2017-10-12 13:47:54	2017-10-12 18:47:54	12690	Galaxy (l=0, b=30)	20:02:16.80	-41:20:31.2	LICK	Rashid Sunyaev	14200

## Observing schedules

### Short Range Observatory Schedule

This is the intended schedule of XMM-Newton observations. This schedule of observations has been generated in the observatory and will be executed unless interrupted by a team decision. Targets of opportunity, or instrument and seasonal constraints. This schedule will cover various time ranges depending on the exposure time of the observations, but will usually be for a period of at least one week.

The XMM-Newton team will be happy to accept requests for observations. All requests should be submitted to the XMM-Newton team via the XMM-Newton website. The XMM-Newton team will be happy to accept requests for observations. The XMM-Newton team will be happy to accept requests for observations.

ObsID	Start Time	End Time	Target	RA	DEC	Filter	PI	Propo
001118	2017-10-10 10:29:15	2017-10-10 17:10:51	Galaxy	17:45:36.00	-26:56:00.0	LICK	Erik Saulkers	14200
001119	2017-10-10 17:13:34	2017-10-11 07:55:55	Galactic Center	17:52:11.21	-25:21:49.7	5x5_Seq	Joem Wilms	14200
001120	2017-10-11 08:16:46	2017-10-11 11:58:32	Galaxy (l=0, b=0)	17:42:23.76	-29:38:02.4	HEX	Rashid Sunyaev	14200
001121	2017-10-11 12:26:36	2017-10-11 12:56:36	Galaxy (l=0, b=30)	20:02:16.80	-41:20:31.2	HEX	Rashid Sunyaev	14200
001122	2017-10-11 13:27:21	2017-10-11 14:29:17	Galaxy (l=0, b=30)	19:59:40.90	-41:05:06.0	LICK	Rashid Sunyaev	14200
001123	2017-10-11 15:00:12	2017-10-11 17:38:07	Galaxy (l=0, b=30)	19:59:40.80	-41:05:06.0	HEX	Rashid Sunyaev	14200
001124	2017-10-11 18:41:00	2017-10-12 08:01:56	GRS 1915+105	19:15:11.79	+10:56:45.7	5x5_Seq	Jerome Rodriguez	14200
001125	2017-10-12 08:01:56	2017-10-12 13:47:54	Galaxy (l=0, b=30)	20:02:16.80	-41:20:31.2	HEX	Rashid Sunyaev	14200
001126	2017-10-12 13:47:54	2017-10-12 18:47:54	Galaxy (l=0, b=30)	20:02:16.80	-41:20:31.2	LICK	Rashid Sunyaev	14200

## Observing schedules

### Long Range Observatory Schedule

This is the intended schedule of XMM-Newton observations. This schedule of observations has been generated in the observatory and will be executed unless interrupted by a team decision. Targets of opportunity, or instrument and seasonal constraints. This schedule will cover various time ranges depending on the exposure time of the observations, but will usually be for a period of at least one week.

The XMM-Newton team will be happy to accept requests for observations. All requests should be submitted to the XMM-Newton team via the XMM-Newton website. The XMM-Newton team will be happy to accept requests for observations. The XMM-Newton team will be happy to accept requests for observations.

Scheduling Unit	Begin UT	End UT	Principal Investigator	Target	RA	DEC	Filter	Propo
2017-289	2017-10-10 10:29:15	2017-10-10 17:10:51	LOCKWOOD	Galaxy	17:45:36.00	-26:56:00.0	LICK	Erik Saulkers
2017-290	2017-10-10 17:13:34	2017-10-11 07:55:55	LOCKWOOD	Galactic Center	17:52:11.21	-25:21:49.7	5x5_Seq	Joem Wilms
2017-291	2017-10-11 08:16:46	2017-10-11 11:58:32	LOCKWOOD	Galaxy (l=0, b=0)	17:42:23.76	-29:38:02.4	HEX	Rashid Sunyaev
2017-292	2017-10-11 12:26:36	2017-10-11 12:56:36	LOCKWOOD	Galaxy (l=0, b=30)	20:02:16.80	-41:20:31.2	HEX	Rashid Sunyaev
2017-293	2017-10-11 13:27:21	2017-10-11 14:29:17	LOCKWOOD	Galaxy (l=0, b=30)	19:59:40.90	-41:05:06.0	LICK	Rashid Sunyaev
2017-294	2017-10-11 15:00:12	2017-10-11 17:38:07	LOCKWOOD	Galaxy (l=0, b=30)	19:59:40.80	-41:05:06.0	HEX	Rashid Sunyaev
2017-295	2017-10-11 18:41:00	2017-10-12 08:01:56	LOCKWOOD	GRS 1915+105	19:15:11.79	+10:56:45.7	5x5_Seq	Jerome Rodriguez
2017-296	2017-10-12 08:01:56	2017-10-12 13:47:54	LOCKWOOD	Galaxy (l=0, b=30)	20:02:16.80	-41:20:31.2	HEX	Rashid Sunyaev
2017-297	2017-10-12 13:47:54	2017-10-12 18:47:54	LOCKWOOD	Galaxy (l=0, b=30)	20:02:16.80	-41:20:31.2	LICK	Rashid Sunyaev

## XMM-Newton Short-Term Schedule

The Short-Term Schedule gives an overview of scheduled observations covering the time range from the past week until the upcoming 2-4 weeks.

Background: The planning and scheduling procedure is described in Sec. 3.2 of the *Policy and Procedures*. In addition, the process of scheduling XMM-Newton observations is described in a [guide to the scheduling star XMM-Newton obs](#).

Definition: Each row lists the revolution number (REV), observation identifier (ObsID), target name, pointing coordinates (right ascension (RA), declination (DEC)), start and stop times, prime instrument, accumulated exposure times (in kiloseconds) in kiloseconds for each instrument (without overhead), and name of the Principal Investigator (PI). The start and stop times refer to the instrument activities required to perform the observation. The exposure times are accumulated over all exposures taken with the same instrument. Especially for UV, the observation can be split in multiple exposures with different instruments (SPI), exposure times in brackets indicate that one or all exposures use the color filter. Details can be seen when clicking on the ObsID.

The normalized flux indicates the target that is scheduled for the time of the last table update. The position data is given at the top of the table.

Filters: The scheduling of an XMM-Newton revolution may have to be revised (see Secs. 3.3, 3.4, and 3.2.2 of the *Policy and Procedures*). Contingency of any type and solar flaring activity may impact at different levels the scheduled programme. The [Contingency Log Browser](#) can be checked to see what was actually done.

Update frequency: Every 6 hours an updated version is updated (new revolution parameters are updated). The latest available version can be viewed after clicking the browser button for the contents of any previous sessions.

LAST UPDATE ON: 2017-10-11 12:42:30 UT (Current Rev = 1872)

Rev #	Obs ID	Target Name	RA	DEC	RA	UTC Obs Start	UTC Obs End	Prime Instr.	PI	MOI	MOI	MOI	MOI	MOI	MOI	PI
1872	001120	ESCI01B006	08:24:27	-37:16:57	18.83	2017-10-10 10:29:15	2017-10-10 17:10:51	EPIC	18.7	18.1	18.5	18.2	18.2	18.3	18.3	Peter Beaman
1872	001121	118 81109	09:21:40	-00:34:17	16.00	2017-10-10 17:13:34	2017-10-11 07:55:55	EPIC	9.5	10.9	10.9	11.0	11.0	10.9	10.9	7800 Evans
1872	001122	zeta Puppi	09:02:40	-40:00:30	112.80	2017-10-11 08:16:46	2017-10-11 11:58:32	EPIC	44.9	44.9	44.9	44.9	44.9	44.9	44.9	Peter James Athey-Newton/MU
1872	001123	09 05	10:11:18	+36:43:17	118.83	2017-10-11 12:26:36	2017-10-11 12:56:36	EPIC	36.6	36.6	36.6	36.6	36.6	36.6	36.6	Guido Rispoli
1872	001124	202017-08-04H008	07:26:27	-18:49:38	81.37	2017-10-11 13:27:21	2017-10-11 14:29:17	EPIC	13.0	12.8	12.8	13.0	13.0	12.8	12.8	Nathan Sorensen
1872	001125	041J019	14:51:55	-17:16:09	156.67	2017-10-11 15:00:12	2017-10-11 17:38:07	EPIC	43.4	44.8	44.8	43.4	43.3	43.7	43.7	Franck Copin
1872	001126	0445-0953	14:49:24	-09:52:24	138.82	2017-10-11 18:41:00	2017-10-12 08:01:56	EPIC	42.9	42.9	42.9	44.1	44.2	42.9	42.9	Patrick Savignat
1872	001127	0055	08:26:10	-11:49:18	101.79	2017-10-12 08:01:56	2017-10-12 13:47:54	EPIC	38.0	33.4	37.4	33.8	37.1	37.3	37.3	Guido Rispoli

What object has been (or will be) observed when and in which wavelength?

# □ VOEvent: Sky Event Reporting Metadata

- “Defines the content and meaning of a standard information packet for representing, transmitting, publishing and archiving information about a transient celestial event, with the implication that timely follow-up is of interest”
  - **Who**: Identification of scientifically responsible Author
  - **What**: Event Characterization modeled by the Author
  - **WhereWhen**: Space-Time Coordinates of the event
  - **How**: Instrument Configuration
  - **Why**: Initial Scientific Assessment
  - **Citations**: Follow-up Observations
  - **Description**: Human Oriented Content
  - **Reference**: External Content



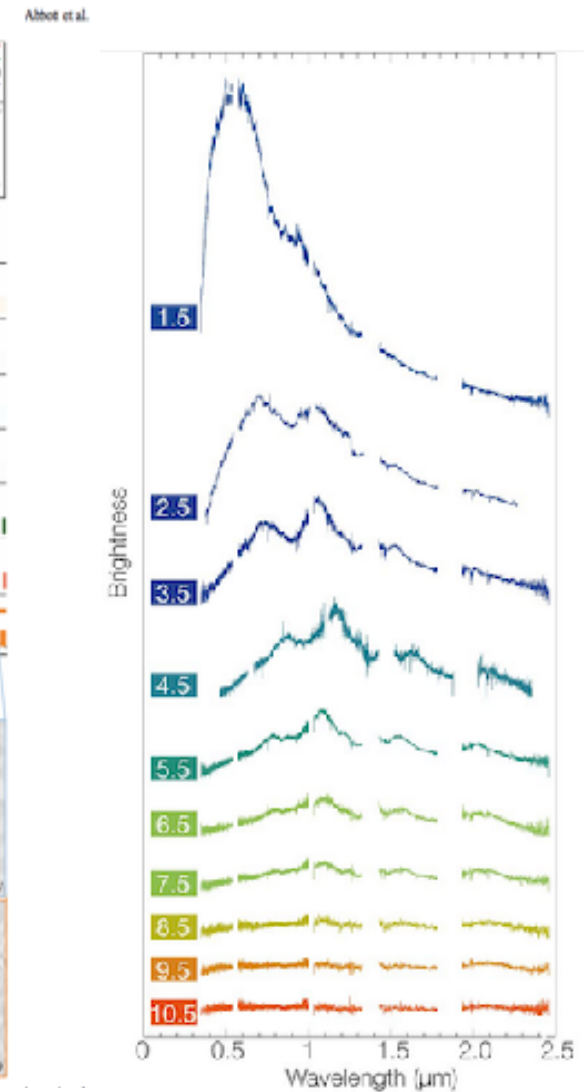
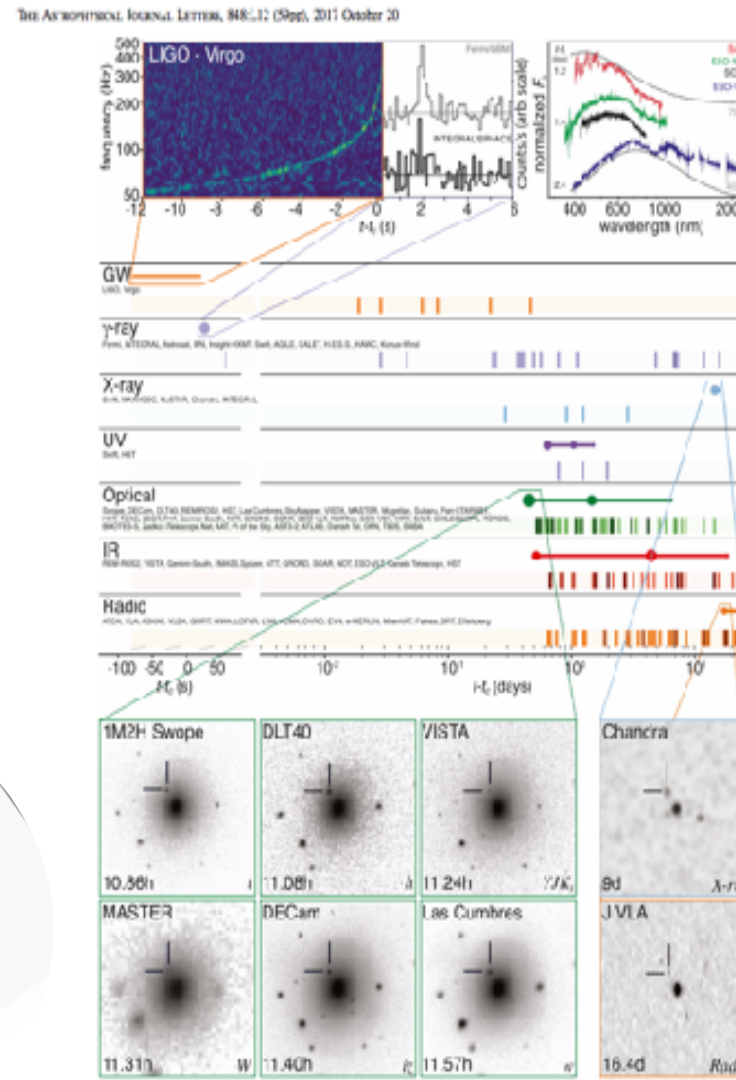
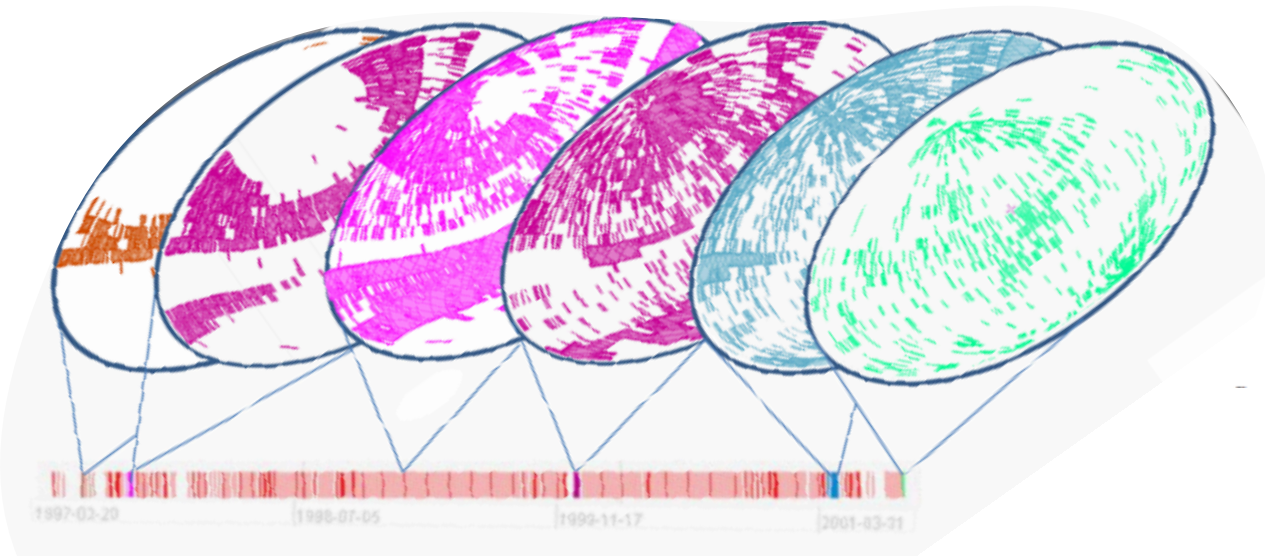
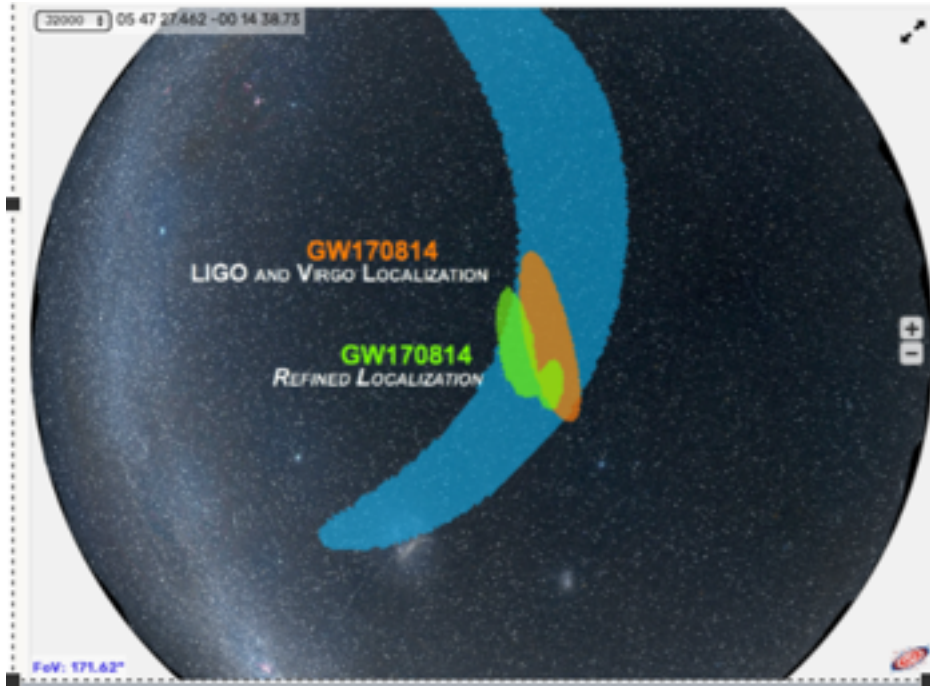
# □ Register your services

- Describe what data and computational facilities are available where, and once identified, how to use them.

- **The yellow pages**



# □ In a multi-messenger landscape



# □ What else?

- Many more standards!
- Want to know more? Don't know what an acronym means?
- Have a look at the architecture document!
  - A summary of each standard plus a table with acronyms
- <https://www.ivoa.net/documents/IVOAArchitecture/20211101/index.html>

## 9.9 SODA

The Server-side Operations for Data Access (SODA) (Bonnarel and Dowler et al., 2017) is an API for low-level data access or server side data processing. The initial version describes operations for extracting a subsection of a data file using astronomical coordinates; Future evolution is expected to include performing various kinds of operations: transformations, pixel operations, and applying functions to the data.

Acronym	Expansion
ADQL	Astronomical Data Query Language - standard
API	Application programming Interface
CDP	Credential Delegation Protocol - standard
CharDM	Characterisation Data Model - standard
ConeSearch	Cone Search - simple positional search service standard



# □ Want to publish your data in the VO?

- Have a look here:
- <https://wiki.ivoa.net/twiki/bin/view/IVOA/PublishingInTheVO>
  - Check the Q&A section! (How do I publish images? spectra? catalogues or generic data tables?...)
- And come to the dedicated panel session

**Tuesday April 26 - 15:00 UTC**

Speaker	Title	Time	Materials
Ada Nebot	Summary of the Project Survey + Intro to the panel	12'	<a href="#">pdf</a>
Dongwei Fan	LAMOST and the China Virtual Observatory	12'	<a href="#">pdf</a>
Tamara Civera	Observatorio Astrofísico de Javalambre: VO Services	12'	<a href="#">pdf</a>
Alberto Micol	European Southern Observatory	12'	
Yan Grange	ASTRON - Netherlands Institute for Radio Astronomy	12'	
All	Open discussion	30'	

# □ Summary

The IVOA standards are built to enable access, discovery and ultimately **interoperability**



Meeting **FAIR**  
principles by design

**The IVOA needs the community to participate!**



# □ Some useful links

- <https://www.ivoa.net>
- Docs : <https://www.ivoa.net/documents/>
- GitHub : <https://github.com/ivoa>
- Mailing list : <https://www.ivoa.net/members/index.html>
- Architecture: <https://www.ivoa.net/documents/IVOOArchitecture/20211101/index.html>
- Slack: [https://join.slack.com/t/ivoa/shared\\_invite/zt-17kd0v93b-b32~KReWd1T96gDyYFDLPQ](https://join.slack.com/t/ivoa/shared_invite/zt-17kd0v93b-b32~KReWd1T96gDyYFDLPQ)